

# **EXHIBIT**

**F**

## AATCC Test Method 8-2016

# Colorfastness to Crocking: Crockmeter Method

**Developed in 1936 by AATCC Committee RA38; revised 1937, 1952, 1957, 1961, 1969, 1972, 1985, 1988, 1996, 2004, 2005, 2007, 2013, 2016; reaffirmed 1945; 1989; editorially revised and reaffirmed 1968, 1974, 1977, 1981, 1995, 2001; editorially revised 1986, 2002, 2008 (with title change), 2009, 2010, 2011. Partly equivalent to ISO 105-X12.**

### 1. Purpose and Scope

1.1 This test method determines the amount of color transferred from the surface of colored textile materials and other dyed materials (i.e., leather) to other surfaces by rubbing.

1.2 Test procedures employing white crocking cloth squares, both dry and wet with water, are given.

### 2. Principle

2.1 A colored test specimen is rubbed with a white crocking test cloth under controlled conditions.

2.2 Color transferred to the crocking cloth is assessed by a comparison with the Gray Scale for Staining [AATCC Evaluation Procedure (EP) 2], the AATCC 9-Step Chromatic Transference Scale (EP8), or Instrumental Assessment of Degree of Staining (EP12), and a grade is assigned.

### 3. Terminology

3.1 **colorfastness**, n.—the resistance of a material to change in any of its color characteristics, to transfer of its colorant(s) to adjacent materials, or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material.

3.2 **crocking**, n.—a transfer of colorant from the surface of a colored yarn or fabric to another surface or to an adjacent area of the same fabric principally by rubbing.

### 4. Safety Precautions

NOTE: These safety precautions are for information purposes only. The precautions are ancillary to the testing procedures and are not intended to be all inclusive. It is the user's responsibility to use safe and proper techniques in handling materials in this test method. Manufacturers MUST be consulted for specific details such as material safety data sheets

and other manufacturer's recommendations. All OSHA standards and rules must also be consulted and followed.

4.1 Good laboratory practices should be followed. Wear safety glasses in all laboratory areas.

### 5. Uses and Limitations

5.1 This method is not recommended for use for carpets or for prints where the singling out of areas may be too small using this method (see 14.1 and 14.2).

5.2 Since washing, drycleaning, shrinkage, ironing, finishing, etc. may affect the degree of color transfer from a material, the test may be made before, after, or before and after any such treatment.

5.3 This method is designed for use with an AATCC crocking cloth as described in 14.5. Alternatively, other adjacent textile substrates may be used as agreed between interested parties.

### 6. Apparatus and Materials (see 14.3)

6.1 Crockmeter (see 14.4 and Fig. 1).

6.2 AATCC Cropping Cloth, cut in 50 ± 1 mm squares (see 14.5).

6.3 AATCC 9-Step Chromatic Transference Scale (EP8) (see 14.6).

6.4 Gray Scale for Staining (EP2) (see 14.6).

6.5 White AATCC Textile Blotting Paper (see 14.6).

6.6 Specimen holder for crockmeter.

6.7 Spiral wire clip for securing crocking cloth to crockmeter finger.

6.8 Crockmeter verification fabric, or in-house fabric with known poor colorfastness to crocking properties, that provides repeatable and predictable crocking results.

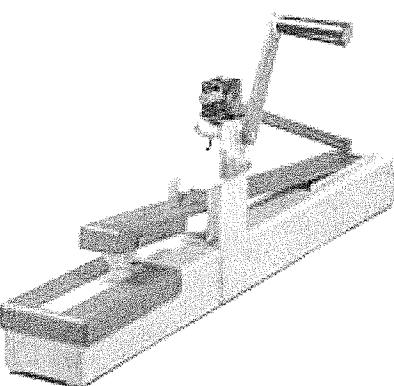


Fig. 1—Crockmeter.

6.9 Emery paper to provide friction on the base of the crockmeter (see manufacturer's recommendations).

### 7. Verification

7.1 Verification checks on the operation of the test and the apparatus should be made routinely and the results kept in a log. The following observations and corrective actions are extremely important to avoid incorrect test results where abnormal crock images can result and influence the rating process (see 14.7).

7.2 Use the crockmeter verification fabric or in-house poor crocking fabric with known predictable and repeatable crocking behavior and conduct three dry and wet crock tests.

7.2.1 A poor circular image with uneven dye pick-up may indicate the crocking finger needs resurfacing (see 14.8).

7.2.2 A double, elongated image may indicate a loose clip (see 14.8).

7.2.3 A stretched and streaked crock image may be due to mounting the crock square diagonally.

7.2.4 Scuff marks to the sides of the specimen indicate the loops of the wire clip are positioned downwards and are not high enough to prevent rubbing the specimen surface.

7.2.5 A streak in the center of the crock cloth image and in the direction of rubbing may indicate damage to the metal base of the device. Contact the manufacturer for recommended solution.

7.2.6 If specimen holder is used, place the holder over the specimen on the tester base. Verify that the holder is not impeding the motion of the finger or coming in contact with it in any way, adjust the holder as necessary to ensure free movement. Without correction, this problem will cause a dark area on one side of the crocking image.

7.2.7 Confirm the wet pick-up techniques (see 10.2).

7.2.8 Replace the abrasive paper on the tester base if it is smooth to the touch in the crocking area compared to the adjacent area, if slippage of the specimen is noticed or if any ridges or bumps are noticed.

7.2.9 In routine testing, observe if multiple streaks are on the crocking image. Position specimen normally with the long dimension oblique to the warp and filling. If the direction of rubbing falls along a twill line or surface pattern, etc., then streaks may occur. If they do occur, slightly adjust the angle for testing.

## 8. Test Specimens

8.1 Two specimens are used, one each for the dry and the wet tests.

8.1.1 Additional specimens may be used to increase the precision of the average (see 13.1).

8.2 Cut the specimens at least  $50 \times 130$  mm and position for testing preferably with the long dimension oblique to warp and filling or wales and courses (see Fig. 2).

8.2.1 Larger or full width lab samples may be used without cutting individual specimens, when multiple tests are needed and when using for production testing. Wherever possible, large samples should be positioned obliquely. If this is not possible, make a note in the report. Avoid seams and other raised areas.

8.2.2 Samples should be prepared in an oblique direction to the warp and weft, neither parallel, right angled or at  $45^\circ$ ; they should be slanted.

8.3 Yarns. Knit a piece of fabric at least  $50 \times 130$  mm and position as per 8.2, or wind yarn tightly on a suitable sample card/plate at least  $50 \times 130$  mm, with the yarn running in the long direction (see 14.9).

## 9. Conditioning

9.1 Prior to testing, precondition and condition the test specimens and the crocking cloth for crock testing as directed in ASTM D1776, Standard Practice for Conditioning and Testing Textiles. Condition each specimen for at least 4 h in an atmosphere of  $21 \pm 2^\circ\text{C}$  ( $70 \pm 4^\circ\text{F}$ ) and  $65 \pm 5\%$  RH by laying each test specimen or crock square separately on a screen or perforated shelf of conditioning rack.

## 10. Procedures

### 10.1 Dry Crocking Test.

10.1.1 Place a test specimen on the base of the crockmeter, flat on the abrasive cloth, with its long dimension in the direction of rubbing.

10.1.2 Place specimen holder over

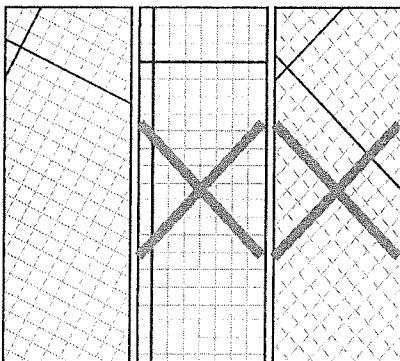


Fig. 2—Oblique alignment of specimen (left).

specimen and apply sufficient tension to avoid slippage or wrinkling.

10.1.3 Mount a crocking cloth square, the warp or weft direction parallel to the direction of rubbing, over the end of the finger that projects downward from the weighted arm. Use the spiral wire clip to hold the square in place. Position the clip with loops upward. If the loops point downward, they can drag against the test specimen.

10.1.4 Lower the covered finger onto the test specimen. For manual crockmeters, beginning with the finger positioned at the front end, turn the handle 10 complete turns at the rate of one turn per second to slide the covered finger back 10 times and forth 10 times. For motorized crockmeters, set and run for 10 complete turns. Refer to individual specifications for any other required number of turns.

10.1.5 Remove the crocking cloth square, condition (see 9.1) and evaluate as directed in Section 11. In the case of napped, brushed or sanded material, when loose fiber might interfere with the rating, remove the extraneous fibrous material by pressing lightly on the crock circle with the sticky side of cellophane tape before evaluating.

### 10.2 Wet Crocking Test.

10.2.1 Weigh a conditioned dry crocking cloth square. Calculate the desired wet weight ( $65 \pm 5\%$  pickup) by multiplying the original dry weight by 1.65.

Apply water evenly over the crocking cloth square and weigh to verify  $65 \pm 5\%$  pickup. If necessary, discard the square with insufficient or excessive weight and use a new crocking cloth square. Repeat this process each day (see 14.10).

An example of how to achieve this pickup is: Using a syringe tube, graduated pipette or automatic pipettor, draw up water in mL to 0.65 times weight of crocking square. Example: If the crocking square weight equals 0.24 g, the mL used would be  $0.24 \times 0.65 = 0.16$  mL. Lay the crocking cloth square on white plastic mesh over a dish. If needed, adjust the amount of water used to wet the square and using a new crocking cloth square, repeat steps. When  $65 \pm 5\%$  wet pickup is achieved, record the amount of water used. Draw up the recorded amount of water into the syringe tube, graduated pipette or automatic pipette for each wet crocking performed during the current day. Other methods are available and can be used.

10.2.2 Avoid evaporative reduction of the moisture content on the crocking cloth square below the specified level of  $65 \pm 5\%$  before the actual crock test is run.

10.2.3 Continue as directed in 10.1.

10.2.4 Air dry the crocking cloth square, then condition (see 9.1) before evaluating. In the case of napped, brushed or sanded material when loose fiber might interfere with the rating, remove the extraneous fibrous material by pressing lightly on the crock circle with the sticky side of cellophane tape before evaluating.

## 11. Evaluation (see 14.11)

11.1 Back the crooked square with three layers of clean crocking cloth for evaluating.

11.2 Rate the amount of color transferred from the specimen to the crock square under examination by means of the AATCC Gray Scale for Staining (EP2), AATCC 9-Step Chromatic Transference Scale (EP8) or Instrumental Assessment of Degree of Staining (EP12) and record the numerical rating (see 14.12 and 14.13).

11.3 Average the individual results to the nearest 0.1 grade when multiple specimens are tested or when a panel of evaluators rate color transfer.

## 12. Report

12.1 State the grades of dry and wet crocking test, unless otherwise requested between parties.

12.2 Report the grade determined in 11.3.

12.3 State whether Gray Scale for Staining (EP2), AATCC 9-Step Chromatic Transference Scale (EP8) or Instrumental Assessment of Degree of Staining (EP12) was used for evaluating staining (see 14.12).

12.4 If any pretreatment or aftertreatment was given to any specimens (see 5.2), indicate method of treatment.

## 13. Precision and Bias (see 14.14)

13.1 *Precision.* An interlaboratory test was conducted in 1986 to establish the precision of the test method. Testing was conducted under the normal atmospheric conditions of each laboratory and not necessarily under ASTM D1776 standard conditions. Two operators at each of 12 laboratories evaluated 5 fabrics in 3 replications by both dry and wet test method.

Table I—Components of Variance

	Dry		Wet	
	Chromatic	Gray	Chromatic	Gray
Single Operator/Rater	0.20	0.20	0.24	0.25
Within Laboratory	0.20	0.19	0.31	0.34
Between Laboratory	0.10	0.17	0.38	0.54

**Table II—Critical Differences**

For the components of variance in Table I, two averages of observed values should be considered significantly different at the 95% probability level if the difference equals or exceeds the following critical differences.

	No. of Observations	Dry		Wet	
		Chromatic	Gray	Chromatic	Gray
Single Operator/Rater	1	0.55	0.54	0.68	0.70
	3	0.32	0.31	0.39	0.40
	5	0.24	0.24	0.30	0.31
Within Laboratory	1	0.77	0.75	1.08	1.17
	3	0.60	0.61	0.93	1.02
	5	0.60	0.57	0.90	1.00
Between Laboratory	1	0.82	0.89	1.53	1.90
	3	0.69	0.77	1.43	1.81
	5	0.66	0.74	1.41	1.79

The critical differences were calculated using  $t = 1.96$  which is based on infinite degrees of freedom.

**Table III—Sample Crock Test Results with Chromatic Scale**

	Dry	Wet
Lab A	4.5	3.5
Lab B	4.0	1.5
Difference	0.5	2.0

Each of 3 raters independently rated the stained crocking cloth squares using both the Gray Scale for Staining and the AATCC 9-Step Chromatic Transference Scale. The original data is on file at the AATCC Technical Center.

13.1.1 The components of variance as standard deviations of the Gray Scale for Staining or AATCC 9-Step Chromatic Transference Scale rating units are given in Table I.

13.1.2 Critical differences are given in Table II.

13.1.3 Example for determining between laboratory differences using one observer and the chromatic scale are given in Table III.

Interpretation: For the dry crock test, since the difference between labs is less than the critical differences in Table II (0.82), the difference in results is not significant. For the wet crock test, since the difference between labs is greater than the critical difference (1.53), the difference in results is significant.

13.2 *Bias*. The true value of colorfastness to crocking can only be defined in terms of a test method. Within this limitation, this test method has no known bias.

#### 14. Notes

14.1 For carpets, AATCC Test Method (TM) 165, Colorfastness to Crocking: Carpets—Crockmeter Method, under the jurisdiction of Committee RA57, Floor Covering Test Methods, should be used.

14.2 For prints where the singling out of ar-

eas too small to test with the standard crockmeter is necessary (see TM116, Rotary Vertical Crockmeter Method). Specimens tested by both test methods may show dissimilar results. There is no known correlation between the two methods.

14.3 For potential equipment information pertaining to this test method, please visit the online *AATCC Buyer's Guide* at [www.aatcc.org/bg](http://www.aatcc.org/bg). AATCC provides the possibility of listing equipment and materials sold by its Corporate members, but AATCC does not qualify, or in any way approve, endorse or certify that any of the listed equipment or materials meets the requirements in its test methods.

14.4 The crockmeter provides a reciprocating rubbing motion simulating the action of a human finger and forearm.

The crockmeter is so designed that the  $16 \pm 0.3$  mm diameter finger moves back and forth, with each complete turn of the crank, in a straight line along a  $104 \pm 3$  mm track on the specimen, with a downward force of  $9 \pm 0.9$  N ( $2 \pm 0.2$  lb).

14.5 AATCC Crocking Cloth should meet the following specifications:

Fiber	100% 10.3-16.8 mm combed cotton staple with no optical brightener present
Yarn	15 tex (40/1 cotton count), 5.9 turns/cm "z"
Thread count	for greige fabric $32 \pm 5$ warp ends/cm; $33 \pm 5$ filling picks/cm
Weave	1/1 plain
Finished fabric	desized and bleached with no optical brightener or finishing material present
pH	$7 \pm 1$
Mass/sq meter	$100 \pm 3$ g finished
Whiteness	$W = 78 \pm 3$ (TM110)

14.5.1 CAUTION: ISO crock test cloth results may not be equivalent to AATCC crocking cloth results/values based on crocking cloth study.

14.6 The AATCC 9-Step Chromatic Transference Scale, Gray Scale for Staining and the White AATCC Textile Blotting Paper are available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: +1.919.549.8141; fax: +1.919.549.8933; e-

mail: [orders@aatcc.org](mailto:orders@aatcc.org); web site: [www.aatcc.org](http://www.aatcc.org).

14.7 For a discussion of crock testing, see the article by J. Patton, "Crock Test Problems can be Prevented," *Textile Chemist and Colorist*, Vol. 21, No. 3, March 1989, p13; and "Testing for Crocking: Some Problems and Pitfalls" by Allan E. Gore, *Textile Chemists and Colorists*, Vol. 21, No. 3, March 1989, p17.

14.8 Accidental damage to the rubbing finger, spiral clip or abrasive paper should be repaired as follows: neatly renew the abrasive paper; bend the clip further open or shut around a rod slightly smaller in diameter than the crock peg; resurface the finger by movement on an extra piece of fine emery cloth in a manner simulating regular use.

14.9 For more convenient crock testing of multiple strands of yarn or thread a dowel attachment is useful. This attachment was developed to avoid the tendency of the standard finger to dig into and push aside the yarns, or slide off them and possibly give erroneous results. This attachment is 25 mm in diameter by 51 mm long. Positioned on its side and held in place by the standard finger, it provides a wider test area, and holds the white test square by two spring loaded clips. For additional information on this development see the article by C. R. Trommer, "Modification of the AATCC Crockmeter for Yarn Testing," *American Dyestuff Reporter*, Vol. 45, No. 12, June 4, 1956, p357; also see articles by S. Korpanty and C. R. Trommer, "An Improved Crockmeter for Yarn Testing," *American Dyestuff Reporter*, Vol. 48, No. 6, March 23, 1959, p40.

14.10 Experienced operators do not have to repeat this weighing procedure during a test session once the technique is established.

14.11 CAUTION: It has been reported that the results for staining obtained by this method on fabrics dyed to dark shades (navy, black, etc.) that contain a combination of polyester and spandex, or their blends, may not show the full staining propensity of such fabrics in consumer use. It is, therefore, recommended that the staining results obtained by this test not be used for the acceptance testing of such fabrics.

14.12 It has been noted that different grades may result depending upon whether the Gray Scale for Staining or AATCC 9-Step Chromatic Transference Scale is used for the evaluation. It is, therefore, important to report which scale was used.

For very critical evaluations and in cases of arbitration, grades must be based on the Gray Scale for Staining.

14.13 An automated electronic grading system may be used as long as the system has been demonstrated to provide results that are equal to and provide equal or better repeatability and reproducibility than an experienced grader performing visual evaluation.

14.14 The precision of this test method is dependent on the combined variability of the material being tested, the test method itself, and the evaluation procedure utilized.

14.14.1 The precision statement in Section 13 was developed from results obtained by visual evaluation (see EP2 and EP8).

14.14.2 It is expected that the use of instrumental evaluation procedures (EP12) will result in greater precision than that obtained from visual evaluations.